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DOCUMENT-IDENTIFIER: US 6676561 B2
TITLE: Torque transfer system for a motor vehicle

Brief Summary Text (24):
The present invention further provides that the control device is designed to manage a start-up phase of the vehicle from a stand-still condition. In a start-up phase, an engine-load control lever, usually a gas pedal, is actuated by the driver so that the drive source runs at a higher rpm rate than the idling speed, and at least a small amount of clutch engagement causes the vehicle to slowly begin to move.

Brief Summary Text (62):
As a notable feature of the invention, the clutch device is controlled by the control device preferably in a such manner that the amount of torque that is transmittable through the clutch is immediately reduced if the transmission rpm rate falls to a predetermined level, known as the clutch-disengagement threshold. By reducing the amount of torque carried through the clutch, the latter will be put into a slipping state, so that the transmission rpm rate and the engine rpm rate will increasingly diverge. As a consequence, in a situation where the vehicle is traveling downhill, the transmission rpm rate may increase because of the torque entering the power train from the output side, while the engine rpm rate changes towards the idling rpm rate, i.e., decreases. At the point where the transmission rpm rate has risen to a predetermined value, which may be set at 1200 rpm, the clutch device is controlled according to another subroutine of the control characteristic. As a preferred possibility for this control phase, the target value for the transmittable clutch torque, which prior to that point was regulated at a constant level, is now controlled by setting separate targets for the portions allocated to slippage and to driving the vehicle. As a result of this control, the target torque value for the transmittable torque is strongly increased. This will cause the transmission rpm rate to decrease and, at least after a certain time, it will cause the gap between the engine rpm rate and the transmission rpm rate to become increasingly smaller, until the two rpm rates are synchronized again.

Brief Summary Text (72):
The start-up rpm rate in the present context is defined in particular as the controlled rpm rate during the start-up phase.

Brief Summary Text (73):
A start-up phase in the sense of the present context is in particular a process in which an engine-load control lever such as a gas pedal is being actuated, where the engine rpm rate is in essence above the idling rpm rate and the vehicle is starting to move at least slowly as the clutch is engaged at least to a minor extent.

Detailed Description Text (16):
The control device is at least part of the time in signal communication with all of the sensors and evaluates the sensor signals and input data which, in their totality, are referred to as the current operating point of the torque transfer system. Based on the operating point, the control device issues control and

regulation command signals to the at least one actuator. The drive element 12 of the actuator, such as an electric motor, operates under the command of the control unit that controls the actuation of the clutch by means of a command signal that depends on the measurement values and/or the system input data and/or signals of the sensors. The control device has a control program in the form of hardware and/or software, which evaluates the incoming signals and calculates or determines the output quantities based on comparisons and/or functions and/or characteristic data arrays or curve fields.

Detailed Description Text (22):
To put the vehicle in motion or to accelerate the vehicle from a stationary or slow rolling condition, the driver has to use only the gas pedal 30, as the controlled or regulated automatic clutch actuation controls the amount of transmittable torque of the torque-transmitting device. The degree of depression of the gas pedal is detected by the gas pedal sensor 31, and the control unit will accordingly implement a more or less forceful or rapid start-up acceleration. The sensor signals from the gas pedal are used as inputs for the control of the start-up phase of the vehicle.

Detailed Description Text (23):
In a start-up phase, the amount of transmittable torque is set as a control target by means of a given function or on the basis of characteristic curves or curve fields that may be functions of the engine rpm rate. The latter may in turn be dependent on other quantities such as the engine torque, that are correlated to the engine rpm rate through a characteristic relationship.

Detailed Description Text (27):
The time profiles shown in FIG. 3 represent the actual clutch torque 300, the transmittable clutch torque 302, the transmission rpm rate 304, and the engine rpm rate 306. A clutch device is controlled by a control device in particular on the basis of a transmittable clutch torque 302 dependent on the transmission rpm rate 304. Particularly in a downhill coasting mode, if the transmission rpm rate 304, which at first runs synchronously with the engine rpm rate 306, has sunk to a predetermined value shown here as 1000 rpm to give a typical example, the transmittable clutch torque is set to a different value according to a changed characteristic. Under the changed control characteristic, the transmittable clutch torque 302 declines strongly as indicated by the portion 308 of the clutch torque profile 302. Particularly during this phase, the transmittable clutch torque is set dependent on a constant value. The decline of the transmittable clutch torque means in particular that the clutch can transmit only a reduced amount of torque. This has the consequence that beginning at the point 310, the transmission rpm rate 304 and the engine rpm rate 306 diverge from each other, so that slippage occurs in the clutch.

Detailed Description Text (28):
As the vehicle is accelerated by gravity along the downward grade, and as the engine-brake effect is at least reduced by the partial disengagement of the clutch, the transmission rpm rate rises strongly at first during the time phase 312. At the same time, the engine rpm rate 306 around 314 approaches the idling rpm rate. As soon as the increasing transmission rpm rate 304 has reached a predetermined value, which is schematically indicated at point 316, the target function for the clutch torque 302 is set anew according to a different characteristic, so that the targeted clutch torque 302 includes in particular a driving portion. This causes the targeted clutch torque to increase in the area 318, so that the clutch is moved increasingly into engagement. The progressive engagement of the clutch device has in particular the consequence that the time gradient of the transmission rpm rate decreases, because the more strongly engaged clutch increases the braking effect of the engine. However, at the beginning the transmission rpm rate continues to increase because the downhill acceleration due to gravity is at first still stronger than the decelerating effect of the gradually engaging clutch.

Subsequently, however, the transmission rpm rate 304 will likewise decline. The engine rpm rate 306 rises from a certain point on, so that after the point 318, the engine rpm rate and the transmission rpm rate are again substantially synchronized.

Detailed Description Text (30):
According to the invention, it is therefore preferred in a downhill travel phase, particularly if the downward grade is steeper than a predetermined angle, to reduce the clutch-disengagement threshold 320, i.e., the level of the transmission rpm rate 304 at which the clutch is taken out of engagement as symbolically indicated by the arrow 322.

Detailed Description Text (31):
FIG. 4 shows an example of a time profile 304 of the transmission rpm rate n.sub.G and of a time profile 306 of the engine rpm rate n.sub.M. The time profiles of FIG. 4 are representative of a downhill travel phase with a vehicle power train of the known state of the art.

Detailed Description Text (32):
As the vehicle is coasting downhill, the engine rpm rate 306 at first decreases synchronously with the transmission rpm rate 304. When a certain rpm rate 330 has been reached, the clutch is progressively taken out of engagement, so that the engine rpm rate 306 will seek the level of the idling rpm rate 332. The transmission rpm rate 304 rises at first, because the vehicle is accelerated by gravity and, as the clutch is progressively retracted from engagement, the braking effect of the engine is progressively diminished. When the clutch is progressively more engaged, the braking effect of the engine will increase, so that the time gradient of the transmission rpm rate sinks and continues into the negative range, while the engine rpm rate 306 rises because of the increasing engagement of the clutch. The engine rpm rate 306 and the transmission rpm rate 304 meet at point 334 and run synchronously during an immediately following time phase. However, during the synchronous time phase, the vehicle is further slowed down by the engine, so that the synchronous rpm rate 304, 306 decreases again to the clutch disengagement threshold 330. As the clutch is moved out of engagement, the rpm rates 304, 306 will again run apart. As soon as the rpm rate 304 has reached a predetermined level, the control device will intervene in the clutch device and cause the time gradient of the rpm rate to decrease, so that the rpm rates 304, 306 will move towards each other, continue synchronously for a limited time, and once again reach the clutch disengagement threshold. In an unfavorable case, this cycle may repeat itself many times over.

Detailed Description Text (33):
FIG. 5 illustrates in a schematic, exemplary manner the time graphs of the engine rpm rate 306 and the transmission rpm rate 304 in a downhill travel phase where a control device according to the invention manages the torque transfer system and in particular the clutch device. After the control device has registered that the vehicle is traveling downhill, the control characteristic for managing the clutch device is modified in such a manner that the threshold rpm rate for clutch disengagement is lowered, as indicated in FIG. 5 by the arrow 342 pointing downward from the level 330 to the reduced level 340. Accordingly, the clutch device does not disengage, particularly when coasting downhill, until the transmission rpm rate has reached the reduced clutch disengagement level 340. The clutch disengagement threshold 340 lies preferably above the idling rpm rate 332. The difference between the idling rpm rate 332 and the clutch disengagement threshold 340 should be selected appropriately, dependent on the principle on which the power source of the vehicle is based.

Detailed Description Text (36):
As a result of lowering the rpm threshold 340 for the clutch disengagement, the time phase is lengthened during which the transmission rpm rate and the engine rpm

rate run synchronously during a downhill coasting phase. It is particularly preferred to set the clutch disengagement threshold 340 at a level where the vehicle ends up traveling at a significantly lower speed.

Detailed Description Text (37):
In the phase 344, the engine-brake effect is significantly larger than the gravity effect, so that the rpm rates 304, 306 show a pronounced decline. In the area indicated by the reference number 346, the rpm rate 304, 306 finds a balanced level slightly above the clutch disengagement threshold 340.

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Brief Summary Text (6):
The term "clutch device" as used herein refers to a device that includes a clutch that can be engaged and disengaged, such as a friction clutch and/or a start-up clutch and/or a reverse-gear clutch and/or a laminar disc clutch and/or a magnet powder clutch and/or a converter bypass clutch. With particular preference, the clutch device is configured as an automated clutch device of the kind which the assignee of the present invention describes and offers for sale under the name "Electronic Clutch Management" (ECM).

Brief Summary Text (7):
A transmission device in the particular context of the present invention means a device by which different transmission ratios can be set. The selection of transmission ratios may be either continuous, i.e., without steps, or it may have a finite number of discrete levels or steps. Examples of transmission devices envisaged here include manual shift transmissions, multi-step transmissions, cone-pulley transmissions and the like. In particular, the transmission device consists of an automatic transmission, preferably of the type that uses a planetary gear mechanism and can be shifted without interrupting wheel traction. As an alternative, the transmission device may also be an automated shift transmission. The term "automated shift transmission" as used herein means a transmission with a gear layout analogous to a manual transmission with the addition of automated controls for at least a part of the shift movements, and in particular for all of the shift movements. An actuating device is provided for the automated controlling of the shift movements, including in particular a hydraulic device with a piston/cylinder arrangement and/or at least one electric motor.

Brief Summary Text (9):
The known state of the art already includes torque transfer systems with an automated clutch device and a transmission device in which the respective shift movements of the clutch device and the transmission device are performed in coordination with each other. Devices of this kind are known in particular for the automated movement of the clutch. Although these known devices are already proven in practical use, it would seem desirable to develop them further to make them more adaptable and more flexible for certain operating states and traction load states of a motor vehicle.

Brief Summary Text (62):
As a notable feature of the invention, the clutch device is controlled by the control device preferably in a such manner that the amount of torque that is transmittable through the clutch is immediately reduced if the transmission rpm rate falls to a predetermined level, known as the clutch-disengagement threshold. By reducing the amount of torque carried through the clutch, the latter will be put into a slipping state, so that the transmission rpm rate and the engine rpm rate will increasingly diverge. As a consequence, in a situation where the vehicle is traveling downhill, the transmission rpm rate may increase because of the torque entering the power train from the output side, while the engine rpm rate changes towards the idling rpm rate, i.e., decreases. At the point where the transmission

rpm rate has risen to a predetermined value, which may be set at 1200 rpm, the clutch device is controlled according to another subroutine of the control characteristic. As a preferred possibility for this control phase, the target value for the transmittable clutch torque, which prior to that point was regulated at a constant level, is now controlled by setting separate targets for the portions allocated to slippage and to driving the vehicle. As a result of this control, the target torque value for the transmittable torque is strongly increased. This will cause the transmission rpm rate to decrease and, at least after a certain time, it will cause the gap between the engine rpm rate and the transmission rpm rate to become increasingly smaller, until the two rpm rates are synchronized again.

Detailed Description Text (3):
The torque-transmitting device 3 is configured as a clutch, such as a friction clutch, laminar disc clutch, magnet powder clutch, or converter bypass clutch. The clutch may be of the self-adjusting, wear-compensating type. The transmission 4 is shown as a manual shift transmission in which the transmission ratio is changed in steps. However, under the concept of the invention, the transmission may also be an automated shift transmission in which the shifting process is automated by means of at least one actuator. The term "automated shift transmission" further means an automated transmission of a type where the tractive force is interrupted during gear shifts and where the shifting from one transmission ratio to another is performed by means of at least one actuator.

Detailed Description Text (4):
It is also possible to use a conventional automatic transmission of the type that works without interrupting traction during gear shifts and is normally based on planetary gear stages.

Detailed Description Text (5):
As a further possibility, a transmission with a continuously variable transfer ratio, such as for example a cone-pulley transmission, may be employed in embodiments of the invention. If a conventional automatic transmission is used, the latter may be equipped with a torque-transmitting device 3, e.g., a clutch or friction clutch, arranged at the output side of the transmission. The torque-transmitting device can further be configured as a start-up clutch and/or as a reverse-gear clutch and/or as a safety clutch in which the magnitude of the transmittable torque can be controlled at a targeted level. The torque-transmitting device can be a dry friction clutch, or a so-called wet-running friction clutch that runs in a fluid, or it may consist of a torque converter.

Detailed Description Text (22):
To put the vehicle in motion or to accelerate the vehicle from a stationary or slow rolling condition, the driver has to use only the gas pedal 30, as the controlled or regulated automatic clutch actuation controls the amount of transmittable torque of the torque-transmitting device. The degree of depression of the gas pedal is detected by the gas pedal sensor 31, and the control unit will accordingly implement a more or less forceful or rapid start-up acceleration. The sensor signals from the gas pedal are used as inputs for the control of the start-up phase of the vehicle.

Detailed Description Text (24):
In a start-up process, essentially from a stationary or crawl-speed condition, if the gas pedal is actuated by an amount a, the engine control 40 will direct the engine to generate an engine torque of a certain magnitude. The control unit of the automated clutch actuation 13 controls the transmittable torque of the torque-transmitting device in accordance with given functions or characteristic curve fields, so that a stationary equilibrium sets in between the engine torque and the clutch torque. The equilibrium is characterized dependent on the gas pedal displacement a by a specific start-up rpm rate, a start-up torque generated by the engine, a specific amount of transmittable torque of the torque-transmitting

device, and a specific amount of traction torque delivered to the drive wheels. The functional relationship between the start-up engine torque and the start-up rpm rate will subsequently be referred to as the start-up characteristic. The gas pedal displacement a is proportionate to the aperture of the throttle valve of the engine.